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NASA TECH BRIEF

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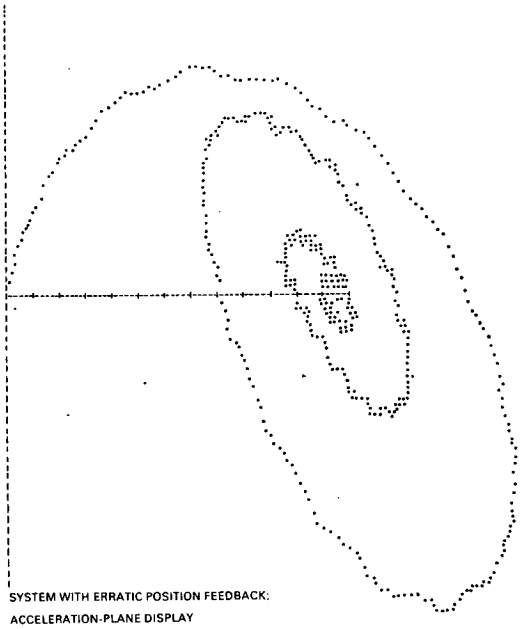
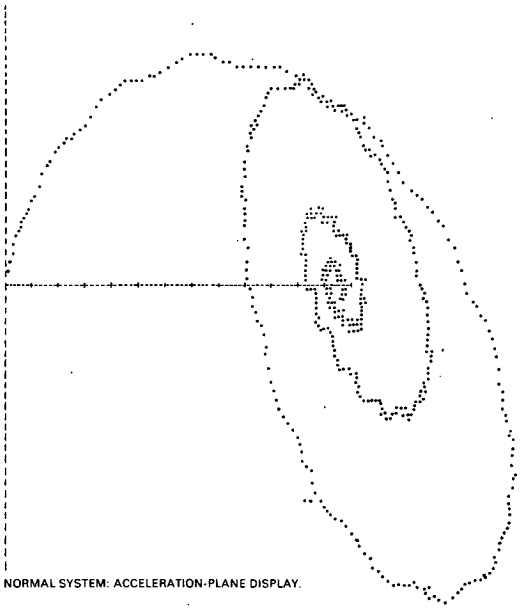
Phase Plane Displays Detect Incipient Failure in Servo System Testing



SYSTEM WITH ERRATIC POSITION FEEDBACK: ACCELERATION-PLANE DISPLAY



NORMAL SYSTEM: ACCELERATION-PLANE DISPLAY.

The problem:

To develop phase plane displays for incipient failure detection in servo system testing, for use in prelaunch checkout of complex nonlinear servomechanisms. Current methods do not provide adequate information on the existence of marginal conditions, unintentional nonlinearities or anomalies in the servo response. Other recent developments, including computerized analysis of servo responses based on classical servo analytical techniques suffer from a common problem: they assume linearity of the servo under test in order to compute transfer function parameter values from response data. This immediately precludes their use in the checkout of servo systems with known nonlinearities (e.g., Saturn-IVB engine gimbal actuators).

The solution:

A computer based, data conditioning and display technique which enables systems test engineers to identify, on line, unusual or abnormal servo responses more easily than is possible with existing strip chart recorders and meters.

How it's done:

A mathematical model of the Saturn-IVB thrust vector control system actuator is used to generate servo response data. After a set of normal plots, in both the amplitude–time and the phase plane formats, are obtained, degradations are simulated in the model and new responses plotted. These are then compared against their respective normal response plots in order to determine the extent of any improvement in detect-

(continued overleaf)

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ing nonnormal or marginal response behavior.

In comparing the two plots, it is readily seen that the general appearance of the acceleration plane plot has undergone the greatest change. Although not illustrated, no essential difference in the pattern of the response in the amplitude-time plots is evident. The gross change in the plot of the system with the erratic position feedback is immediately apparent in the upper section of the curve, which shows the wide separation between the two sections of the spiral.

Notes:

1. The response can be displayed compactly in the time domain on a cathode ray tube.
2. Responses from systems of any complexity, whether linear or nonlinear, can be analyzed with equal facility.
3. Generation of the phase plane displays does not require large scale computing facilities or extensive computer time.
4. A possible industrial application would be the production line testing of servomechanisms.
5. Medical applications might include the diagnostic display of EKG and EEG data.
6. Inquires concerning this invention may be directed to:

   Technology Utilization Officer
   Headquarters
   National Aeronautics and Space Administration
   Washington, D.C. 20546
   Reference: B67-10662

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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